Requested Patent: GB1313928A

Title: APPARATUS FOR CONTROLLING THE POSITION OF MARINE CRAFT ;

Abstracted Patent: GB1313928 ;

Publication Date: 1973-04-18 ;

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Applicant(s): DECCA LTD ;

Application Number: GBD1313928 19700604 ;

Priority Number(s): GB19700027046 19700604 ;

IPC Classification: G05D1/02 ;

Equivalents: ;

ABSTRACT:

1313928 Automatic position control of floating vessels DECCA Ltd 6 Sept 1971 [4 June 1970] 27046/70 Heading G3R [Also in Division G4] The position of a marine craft 10 (an oil tanker) relative to a reference point, e.g. on a drilling platform, and its heading, are controlled by at least two directional thrusters 13 which are operated in response to co-ordinate error signals derived from a range and bearing determination system comprising at least a transmitter and receiver 14 on the vessel co-operating with a transponder 15 at the reference point in con- junction with signals representing the desired position with respect to the reference point, and to a compass heading signal. The thrusters may be directionally adjustable propellors, but pre- ferably are vertical blade, vertical axis pro- pellors of adjustable pitch. Three control signals are derived, namely compass heading error and position errors in the fore-and-aft and athwart- ships directions respectively. The two latter signals are produced by an "error signal unit" having inputs of desired bearing and range, the compass, and the actual bearing and range. In Fig.2 (not shown) both the latter are determined by transmitting radio waves from a rotating, directional aerial, modulated at low frequency, which are returned by the transponder 15 (which is battery powered). The received signal is compared in phase with that transmitted to deter- mine range, the bearing being obtained from the instantaneous position of the aerial at reception. In Fig. 3 (not shown) the transmitter is of radar type, using a non-directional aerial, and is used for range only. For bearing determination a vertically fan-shaped laser beam is produced and continuously rotated about a vertical axis by a device which also produces bearing data pulses. Reflectors are set up on the vessel and at the reference point and the number of pulses which occur between reception from the two reflectors are counted, the count being a measure of the bearing.

PATENT SPECIFICATION (11) 1 313 928

DRAWINGS ATTACHED

1 313 928

(21) Application No. 27046/70 (22) Filed 4 June 1970

(23) Complete Specification filed 6 Sept. 1971

(44) Complete Specification published 18 April 1973

(51) International Classification G05D 1/02

(52) Index at acceptance

G3R 31X 32A1 32E 32P 32R 4 69 7R 9D 9E
G4H 14B 1D 4A 5D 6B 6D 6F 7B 7G 8E

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(54) IMPROVEMENTS IN OR RELATING TO APPARATUS FOR CONTROLLING THE POSITION OF MARINE CRAFT

(71) We, DECCA LIMITED, a British Company, of Decca House, 9 Albert Embankment, London, S.E.1, do hereby declare

the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to apparatus for automatically controlling the positioning of a marine craft with respect to a fixed structure or another ship.

It is often required to hold a ship a short distance away from a fixed structure or possibly another ship, for example, for loading or unloading an oil tanker at a supply terminal or pipeline on a structure, e.g. a drilling rig, to which the ship cannot be moored.

In our earlier Specification No. 1,173,442, there is described and claimed apparatus for controlling the positioning of a water-borne vessel comprising the combination, in the vessel, of at least two vertical blade vertical axis variable pitch propellers spaced apart in the vessel, a receiver for a radio position fixing system providing two electrical output signals representing the co-ordinates of the position of the vessel, means determining the heading of the vessel, position signal generating means providing time-varying output signals representing the co-ordinates of a required position of the vessel which position changes with time to represent the required track of the vessel, error determining means comparing the signals from the said receiver with the signals representing the required position and providing co-ordinate error signals, resolving means controlled by the heading determining means for resolving said error signals into components along the fore-and-aft and athwartships axes of the vessel and control means controlling the pitch of said propellers in accordance with the error signal components from said resolving means so that the propellers move the vessel in a direction to minimise the error signals.

More particularly there is described apparatus in which the radio position fixing system is a two-range system in which equipment on the vessel co-operates with two slave stations at known spaced locations. Such apparatus can thus be used in areas where the necessary radio position fixing facilities are available at suitable known locations.

It is an object of the present invention to provide an improved form of apparatus for holding a vessel at a preselected position a short distance away from a fixed point or another vessel.

According to the present invention, apparatus for controlling the position of a marine craft comprises the combination in the craft of at least two directional thruster units spaced apart in the craft, a range and bearing determination system having a transmitter and a receiver on the craft co-operating with a transponder beacon at a reference point to determine the range from the transporter beacon and having means for determining the bearing of the reference point from the vessel, compass means on the craft to determine the heading of the craft, error determining means utilising the measured range and bearing together with the compass heading in conjunction with signals representing the required position of the craft with respect to the reference point to provide coordinate error signals, and control means controlling the direction of thrust of said directional thruster units in accordance with the coordinate error signals so that the thruster units move the craft in a direction to minimise the error signals and to maintain the required heading of the craft.

With the apparatus of the present invention, apart from the equipment on the vessel, it is necessary to have suitable transponder means at one reference point only; as will be described later, these means may be portab-

so that a vessel can be readily held at any required distance and bearing from a chosen point without any necessity for permanent radio position fixing means at fixed locations.

The directional thruster units may be propeller units giving a horizontal thrust, the units each being mounted for rotation about a vertical axis to enable the direction of thrust to be controlled. Conveniently however vertical blade vertical axis propellers with variable pitch blades are employed enabling the direction and magnitude of the thrusts applied to the craft by each propeller to be controlled by adjustment of the pitch of the blades as they rotate. Two such propellers, one in the bows and the other in the stern, may be adequate but, for large vessels, it is preferred to employ four such propellers, one on each side of the vessel at the bows and one on each side of the vessel at the stern. Control of these directional thruster units enables the heading of the craft to be controlled automatically as well as permitting adjustment of the position of the craft by movement in any direction as required.

Preferably the direction thruster units are retractable so that, when not required for use, they may be withdrawn into the hull of the craft to reduce drag.

The transponder is conveniently made as a self-powered, e.g. battery-powered, portable unit. For the short ranges required for holding-off tankers whilst loading or unloading, this portable transponder unit may be carried on the tanker and, when the vessel arrives at the loading or unloading station, slung by means of a derrick onto the loading or unloading station. The aerial system for the transponder need not be highly directional and therefore it need not be accurately aligned. If a directional aerial is employed for the transponder, provision may be made for adjusting it to the required direction, either manually on setting up the equipment at the reference point or automatically, e.g. by a remote control system from the craft or the aerial may be aligned automatically on the transmitter on the craft.

The range and bearing determination system may comprise radio range determining means and a separate bearing determination means. In this case, the bearing determination means may comprise a means on the craft producing a laser beam, the beam being fan shaped in a vertical plane and rotated about an upright axis, first beam reflector means on the craft, second beam reflector means at the reference point, light responsive means on the craft for receiving the reflected laser beam from said reflectors, and means for determining the difference between the angular directions of the beam at the instants when reflected signals are received from the two reflectors by said light responsive means.

Alternatively the range and bearing determination system may comprise a radio system determining both range and bearing, the receiver on the craft employing a directional receiving aerial and, in this case, aligning means may be provided on the craft responsive to the received signals for automatically maintaining the direction of the receiving aerial on the craft aligned on the transponder at the reference point.

The radio range and bearing determination system may be a radar system, the transponder being a radar transponder.

More generally however, it is convenient to use a pulsed radio transmitter on the craft and time delay measuring means for measuring the time delay between the transmission of pulses and the reception of corresponding signals from the transponder.

In another arrangement, the radio range and bearing determination system is a low frequency phase comparison system with the low frequency signals modulated onto much higher frequency signals so permitting of highly directional aerials being employed. In this case, directional aerials may be employed for the transmitter and receiver on the vessel and these aerials are preferably mounted together so that they point in the same direction and provision is made for automatically keeping the receiving aerial aligned on the transmitter on the reference point. The aerial system on the craft may be connected to a bearing data transmitting system for transmitting the bearing data to a control unit where the bearing data is combined with the heading data, for example from a remote transmitting gyro compass, to determine the bearing of the reference point from the craft. The range and bearing determinations may then be compared with the range and bearing values for the required position of the craft, set in with adjustable controls, to provide the error signals.

Conveniently resolving means are provided for resolving the error signals into components in the fore-and-aft and athwartships directions of the craft to provide position error control signals and, for controlling the heading of the craft, a comparator may be provided to give a heading error signal by comparing the heading of the craft as determined by the compass with the required heading set on a manual control. The heading error signal may be applied to both bow and stern propellers so as to give thrusts in opposite athwartships direction to adjust the heading of the vessel. The position error signals may likewise be applied to appropriate propellers to move the vessel in the required direction.

In the following description, reference will

be made to the accompanying drawings in which:—

Figure 1 is a diagram illustrating the position in which an oil tanker is to be held with respect to a drilling rig;

Figure 2 is a block diagram illustrating one form of equipment employed for controlling vertical blade vertical axes propellers on a vessel; and

Figure 3 is a block diagram similar to Figure 2 but illustrating another form of equipment.

In Figure 1 there is shown a tanker 10 which has to be held close to a drilling rig having a platform 11 on four legs 12. For the transfer of oil, the tanker has to be held close to the drilling rig. The tanker however cannot be moored to the rig and it must not come in contact therewith. For the positioning of the tanker, it is provided with two directional thruster units, e.g. variable pitch vertical blade vertical axis propeller units 13. In some cases, it may be preferred to provide four such units; these directional thruster units may be retractable into the hull to reduce drag when they are not in use. The propeller units are controlled, as will be described with reference to Figure 2, by a radio range and bearing determining system which includes a transmitter and receiver unit 14 on the tanker and a transponder unit 15 on the platform 12. The transponder unit 15 is a portable battery-powered unit which would be carried by the vessel until it was required for use. It may readily be slung from a derrick and deposited on the platform 11. The transponder unit has an aerial which may be directional; if so the unit has to be positioned with the aerial facing in the required direction towards the transmitter and receiver unit 14 on the vessel. In this case, the unit, or its aerial may be positioned manually or remote control means may be provided for controlling, from the vessel, the bearing of the transponder aerial.

Referring to Figure 2, the portable transponder unit at the reference point is shown at 20 with a receiving and re-transmitting aerial 21. The remainder of the equipment is on the vessel. This includes a transmitter 22 for transmitting signals to the transponder and a receiver 23 for receiving signals from the transponder using a directional aerial 24 which is rotatably driven by a bearing drive 25. In this particular embodiment, the range determination is effected by a phase comparison system. Low frequency continuous wave signals are modulated in the transmitter 22 onto a much higher frequency, conveniently a microwave frequency and are transmitted to the transponder 20 which receives and re-radiates the low frequency signals as a modulation on a different carrier frequency. The transponder includes phase control means for holding the phase of the re-radiated low frequency modulation fixed with respect to the received modulation signals.

On the vessel, the re-transmitted signals are received by the directional aerial 24 and fed to the receiver 23 where they are de-modulated and fed to a phase comparator 26 to be compared in phase with the originally transmitted modulation to provide an output representative of the range to the transponder; this output is fed to an error signal unit 27. Into this unit 27 are fed also a required range signal from an adjustable signal generator 28 producing a signal representative of the required range, a heading signal from a gyro transmitting compass 29, a required bearing signal from an adjustable bearing signal transmitter 30 and bearing data from a bearing data transmitter 31. The bearing data transmitter 31 provides a signal representative of the actual bearing of the receiving aerial 24 from the transponder aerial 21 and, for this purpose, the aerial 24 is kept automatically aligned on the transponder transmissions utilising an automatic bearing control unit 32 which is responsive to the received signals and controls the bearing drive 25 to maintain the aerial alignment.

The error signal unit combines the input signals from the compass with the determined range and bearing to give position signals in orthogonal coordinates which are compared with the signals representing the required position to give position error signals in the direction of the heading of the vessel and transversely thereto. These position error signals are fed to position error signal amplifiers 33 and 34. A heading error signal amplifier 35 provides an output obtained from the gyro compass 29 and a required heading signal generator 36. The three signal amplifiers 33, 34 and 35 provide inputs to a combining and resolving unit 37 providing control signal outputs on leads 38 for the directional thruster units.

Figure 3 illustrates another form of equipment using a pulse transmitting system for range determination. In Figure 3, the same reference numerals are used as in Figure 2 to indicate similar components. In the following description reference will only be made to the distinctive features of Figure 3.

A pulse transmitter 40 radiates short duration radio pulses from an aerial 41 on the craft. These are received by a transponder 42 and, after a fixed delay, are retransmitted back to a receiver 43 on the craft. The transmitted pulses may be coded and the transponder arranged to respond only to the selected code. Similarly the transponder may radiate a coded response which is decoded by the receiver 43. The time delay of the transmission path is determined by time

delay determination means 44, the output of which is fed as range data to the error signal unit 27.

The pulse signal receiver 43 may employ a directional aerial for determining bearing data in the manner described with reference to Figure 2. In Figure 3 an alternative arrangement is illustrated using a separate bearing determination system, thereby enabling a non-directional aerial 41 to be used for the range measuring equipment. The bearing determination is effected, in the arrangement of Figure 3, by using a laser 45, the beam of which is made fan-shaped in a vertical plane by a lens 46. The laser beam is rotated continuously about an upright axis by a bearing drive 47. A first reflector 48 is mounted on the craft and a second reflector 49 is put at the reference point. The light from the laser beam is reflected back from these reflectors 48, 49 to a photo-sensitive receiver 50 and the two signals forming the output from this receiver 50 are used to start and stop a counter 51 counting pulses from a bearing data transmitter 52 driven in synchronism with the rotation of the laser beam. The counter output thus provides a bearing measurement which is fed to the error signal unit 27. The error signal unit receives also an input from a compass 29, and required range, bearing and heading inputs from units 28, 30 and 36 and processes these signals, as described with reference to Figure 2, to control the directional thrusters.

WHAT WE CLAIM IS:—

1. Apparatus for controlling the position of a marine craft comprising the combination in the craft of at least two directional thruster units spaced apart in the craft, a range and bearing determination system having a transmitter and receiver on the vessel co-operating with a transponder beacon at a reference point to determine the range from the transponder beacon and having means for determining the bearing of the reference point from the vessel, compass means on the vessel to determine the heading of the craft, error determining means on the vessel utilising the measured range and bearing together with the compass heading in conjunction with signals representing the required position of the craft with respect to the reference point to provide coordinate error signals, and control means controlling the direction of thrust of the directional thruster units in accordance with the coordinate error signals so that the thruster units move the craft in a direction to minimise the error signals and to maintain the required heading of the craft.

2. Apparatus as claimed in claim 1 wherein the range and bearing determination system comprises radio range determining means and a separate bearing determination means.

3. Apparatus as claimed in claim 2 wherein the bearing determination means comprises means on the craft producing a laser beam, the beam being fan-shaped in a vertical plane and rotational about an upright axis, first beam reflector means on the craft, second beam reflector means at the reference point, light responsive means on the craft for receiving the reflected laser beam from said reflectors, and means for determining the differenec between the angular directions of the beam at the instants when reflected signals are received from the two reflectors by said light responsive means.

4. Apparatus as claimed in claim 3 wherein the means for determining the difference between the angular directions comprises a counter for determining the rotational angular movement during the time interval between the reception of reflected signals from the two reflectors.

5. Apparatus as claimed in claim 1 wherein the range and bearing determination system comprises a radio system determining both range and bearing, the receiver on the craft employing a directional receiving aerial and wherein aligning means are provided on the craft responsive to the received signals for automatically maintaining the direction of the receiving aerial on the craft aligned on the transponder at the reference point.

6. Apparatus as claimed in claim 5 wherein the radio range and bearing determination system is a radar system, the transponder being a radar transponder.

7. Apparatus as claimed in any of claims 1 to 5 wherein the range and bearing determination system includes a pulsed radio transmitter on the craft and time delay measuring means for measuring the time delay between the transmission of pulses and the reception of corresponding signals from the transponder.

8. Apparatus as claimed in claim 5 wherein the radio range and bearing determination system is a low frequency phase comparison system with the low frequency signals modulated onto radio frequency signals of much higher frequency.

9. Apparatus as claimed in claim 8 and having directional aerials for both the transmitter and receiver, these aerials being mounted together so that they point in the same direction.

10. Apparatus as claimed in any of the preceding claims wherein resolving means are provided for resolving the error signals into components in the fore-and-aft and athwartships directions of the craft to provide position error control signals and wherein, for controlling the heading of the craft, a comparator is provided to give a heading eror signal by comparing the head-

ing of the craft as determined by the compass with the required heading set on a manual control.

11. Apparatus as claimed in any of the preceding claims wherein the transponder is made as a self-powered portable unit.

12. Apparatus for controlling the position of a marine craft substantially as hereinbefore described with reference to Figures 1 and 2 or Figures 1 and 3 of the accompanying drawings.

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Printed for Her Majesty's Stationery Office by Burgess & Son (Abingdon), Ltd.—1973.
Published at The Patent Office, 25 Southampton Buildings, London, WC2A 1AY
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1313928 COMPLETE SPECIFICATION
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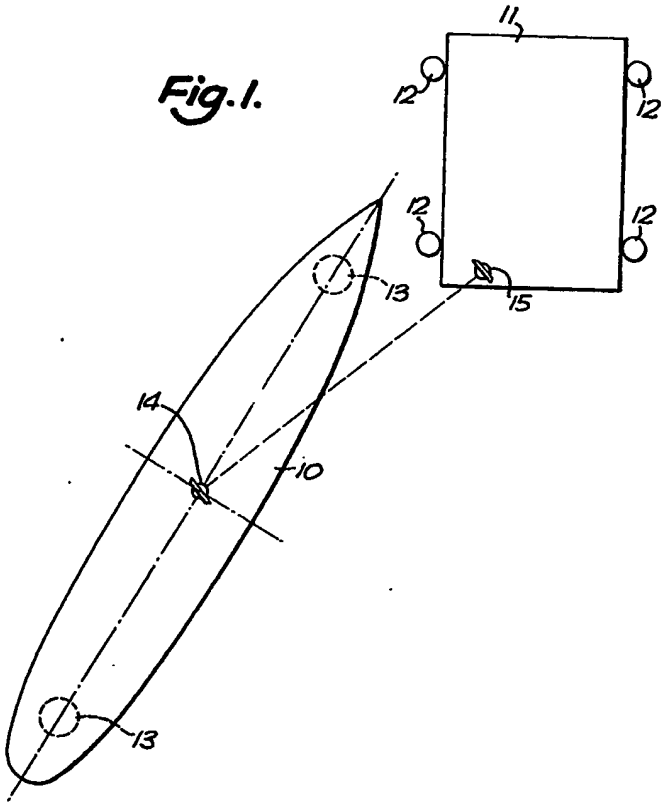
Sheet 1

Fig. 1.



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Sheet 2

Fig.2.

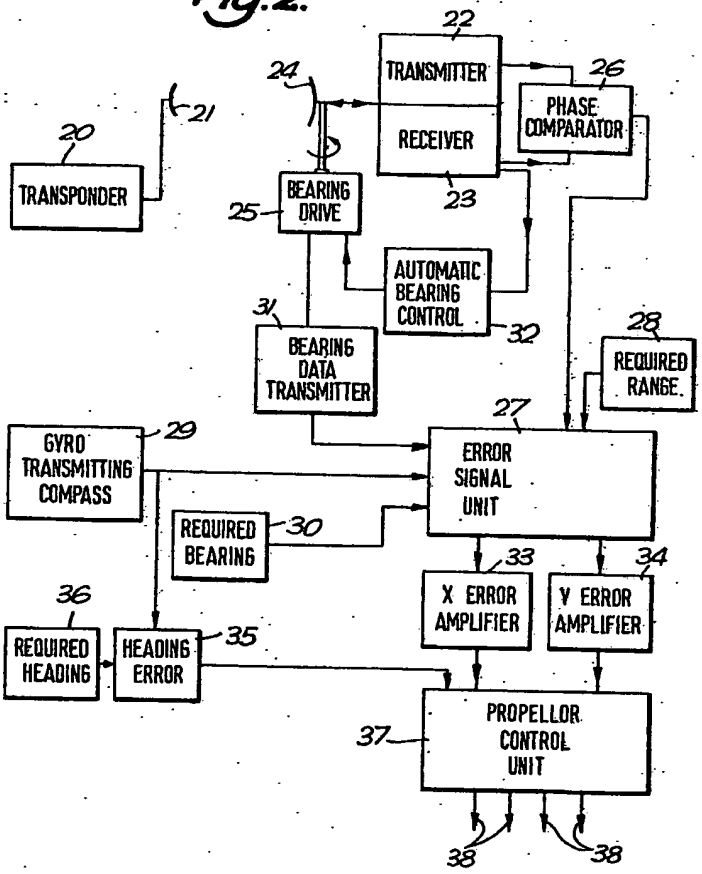
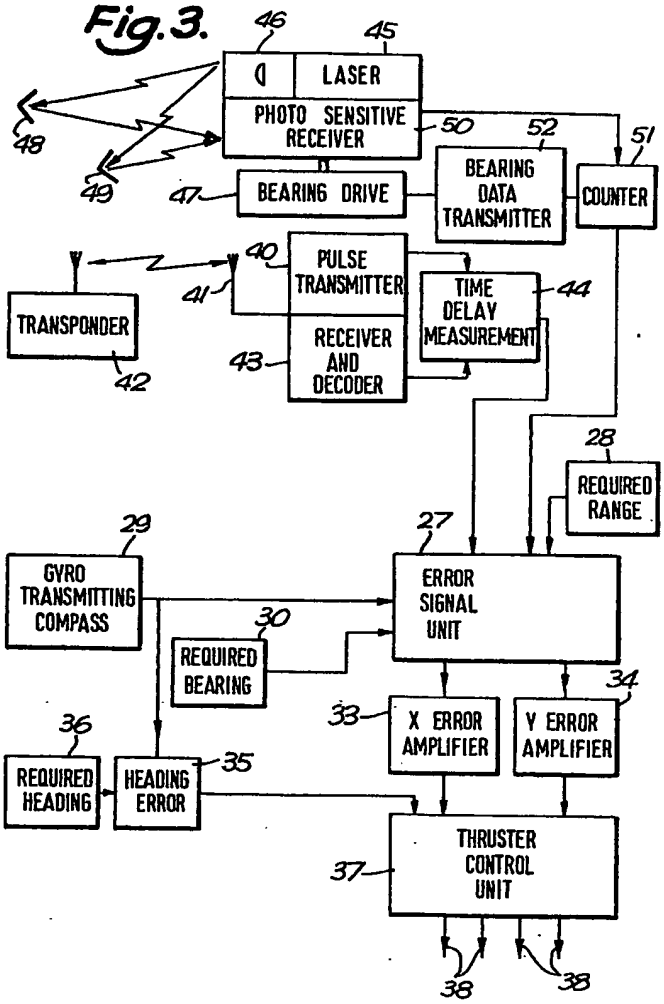


Fig.3.


46
45
LASER
PHOTO SENSITIVE RECEIVER
48
49
50
52
51
47
BEARING DRIVE
BEARING DATA TRANSMITTER
COUNTER
40
PULSE TRANSMITTER
41
TRANSPONDER
42
TIME DELAY MEASUREMENT
44
43
RECEIVER AND DECODER
28
REQUIRED RANGE
29
27
GYRO TRANSMITTING COMPASS
ERROR SIGNAL UNIT
30
REQUIRED BEARING
34
33
X ERROR AMPLIFIER
Y ERROR AMPLIFIER
36
35
REQUIRED HEADING
HEADING ERROR
THRUSTER CONTROL UNIT
37
38
38